REMARKS

Applicant respectfully requests reconsideration of this application as amended. Claims 1-6, 8, 9, and 24 are canceled. Claims 7, 10-23, and 25-29 are currently pending in this application.

Claim Rejections - 35 U.S.C. §103(a)

Claims 7, 14-17, 19-23, and 25-29 have been rejected under 35 U.S.C. §103(a) as being unpatentable over *Reinhardt* (U.S. Patent No. 6,747,243) in view of *Allen* (U.S. Patent Publication 2004/0182416) and *Yogev* (U.S. Patent No. 6,799,584).

Claims 10-11 have been rejected under 35 U.S.C. §103(a) as being unpatentable over *Reinhardt*, *Allen*, and *Yogev*, as stated above and further in view of *Borden* (U.S. Patent No. 6,066,032).

Claims 10-11 have been rejected under 35 U.S.C. §103(a) as being unpatentable over *Reinhardt*, *Allen*, and *Yogev*, as stated above and further in view of *Franca* (U.S. Patent No. 6,217,422).

Claims 12-13 have been rejected under 35 U.S.C. §103(a) as being unpatentable over *Reinhardt*, *Allen*, and *Yogev*, as stated above and further in view of *Patel* (U.S. Patent Publication 2003/0057192).

Claim 18 has been rejected under 35 U.S.C. §103(a) as being unpatentable over *Reinhardt*, *Allen*, and *Yogev*, as stated above and further in view of *Vaught* (U.S. Patent No. 5,023,424).

Response to 35 U.S.C. §103(a) rejections

With regard to the rejection of claims 7, 10-23, and 25-29 under 35 U.S.C. §103(a) as being unpatentable over *Reinhardt* in view of *Allen* and *Yogev*, applicant submits that the combination of prior art references of *Reinhardt*, *Allen* and *Yogev* would not render the present invention obvious because these references fail to teach an element of the present invention, namely causing the particle defect to undergo an explosive evaporation, which comprises evaporation and fragmentation of the particle defects.

The present invention presents a laser beam providing energy to a particle defect to cause the defect to undergo explosive evaporation, defined as partially evaporation and

partially fragmentation. Thus in the laser ablation process according to the present invention, the particle partially vaporizes and partially breaks into smaller particle fragments.

Applicant submits that *Reinhardt* fails to teach evaporating and fragmentizing the particle defects using a laser beam. *Reinhardt* is silent with respect to evaporate and fragmentize the particle defect, and employs a laser beam to provide thermal shock (*Reinhardt*, Col. 11, line 37; Col. 11, lines 47-48), where the particle undergoes rapid temperature changes, generating expansion/contraction at the contacting surfaces, reducing the adhesion of the particle to the substrate surface, and thus struck loose and may be carried away by a nitrogen flow (*Reinhardt*, Col. 11, lines 66-67). Thus applicant submits that *Reinhardt* discloses a laser process where the particle defect is removed intact, and not evaporated or fragmentized.

Further, *Reinhardt* teaches that the laser tool removes the particles indiscriminant of materials or composition (Reinhardt, Col. 11, line 45-46), and therefore it is not necessary to adjust or change the laser beam based on the composition of the defect. Thus applicant submits that *Reinhardt* teaches away from the invention of using the laser beam to evaporate the defect, since the energy needed for evaporation is highly dependent on materials or compositions.

It is appreciated that the Examiner also acknowledges that *Reinhardt* fails to teach explosive evaporation (Office Action dated 7/24/2008, page 3).

With regard to *Allen*, applicant submits that *Allen* is also silent with respect to evaporating and fragmentizing the particle defect. *Allen* discloses a process of coating the substrate surface with a transfer medium, and then using a pulsed energy beam to cause explosive evaporation of the transfer medium (Paragraph [0039], line 11). The particle defect is removed intact; only the transfer medium undergoes explosive evaporation, which lifts off the transfer medium layer together with the intact, embedded particle defect (Paragraph [0039], lines 13-14; Fig. 2C). Thus applicant submits that *Allen* discloses an explosive evaporation of the <u>transfer medium</u> at the substrate surface, which generates enough energy to explosively pushing the transfer medium with the intact embedded defects from the substrate surface. *Allen's* laser process does <u>not</u> cause the

particle defect to undergo an explosive evaporation, and does <u>not</u> cause evaporation or fragmentation of the particle defect.

The Examiner stated that *Allen* teaches that explosive evaporation is used to remove particles with substantial force, and that a thermal expansion velocity removes the particle. Applicant submits that the explosive evaporation process of *Allen* is directed toward the transfer medium/substrate interface, which lifts the transfer medium away from the substrate. The particle defect is embedded in the transfer medium and thus is removed intact with the transfer medium. Thus applicant submits that *Allen* teaches explosive evaporation of the transfer medium and fails to teach explosive evaporation of the particle defect, which comprises evaporation and fragmentation.

Thus applicant submits that *Allen* fails to teach explosive evaporation of the defect particle by laser ablation, and also fails to teach evaporation and fragmentation of defect particle by laser ablation.

In the Response to Argument, the Examiner disagreed with Applicant's argument that *Allen* does not teach explosive evaporation because *Allen* discloses: *Explosive evaporation is used to remove particles with substantial force, that is, a thermal expansion velocity removes the particles.*

Applicant submits that *Allen* discloses explosive evaporation on the transfer medium, which lifts the transfer medium off the surface of the substrate, carrying away the embedded particles. The embedded particles are removed intact, e.g., the particles are not affected by the explosive evaporation process. Thus applicant submits that *Allen* fails to teach explosive evaporation <u>of the particle defects</u>, which is an element of the present claims: "causing the particle defects to undergo explosive evaporation, the explosive evaporation comprising evaporation and fragmentation of the particle defects."

As shown in Figs. 2A-2C, together with the associated paragraph [0039], a transfer medium 23 is deposited on the surface 21 of the substrate 20 in and around the particle 22. A pulsed energy is directed at the surface 21, absorbed in the substrate and/or transfer medium, and causes explosive evaporation on the medium, lifting most of the transfer medium, with the embedded particle, off the surface of the substrate (see Fig. 2C).

... A quantity of energy is absorbed in the substrate and/or energy transfer medium, which is sufficient to cause explosive evaporation on the medium. When explosive evaporation occurs in a thin layer near the substrate surface, most of the energy transfer medium is lifted off the surface of the substrate, as shown in FIG. 2C. Using the system described below, if the thickness L of the energy transfer medium is of a sufficient dimension, drag forces F_{DRAG} function to pull the particle(s) from the surface 21 of the substrate. (Allen, paragraph [0039])

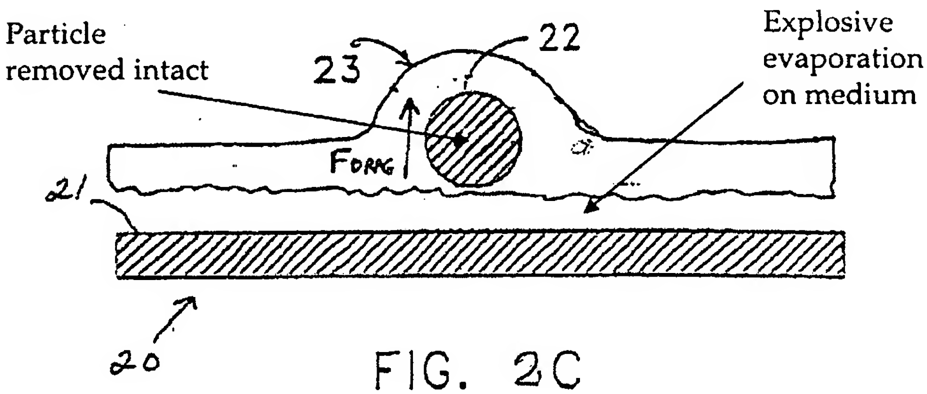

FIG. 2C

Allen, Fig. 2C

Thus applicant respectfully disagrees with the Examiner, and submits that *Allen* fails to teach explosive evaporation of the particle defects, which is defined as evaporation and fragmentation of the particle defects.

With regard to *Yogev*, applicant submits that *Yogev* is silent with respect to evaporating the particle defect with the laser. *Yogev* discloses coating the particles on the semiconductor substrate with a fluid and then applying suction to release and remove the particles from the surface. *Yogev* found that wetting the surface prior to applying suction is more effective in removing particles than applying suction alone. *Yogev* also discloses applying laser energy to the surface to aid in the release of the particles from the surface. There is no mentioning of evaporating the particle defect with the laser.

Further, with regard to defect fragmentation, applicant submits that *Yogev* teaches away from defect particle fragmentation by a laser ablation process. *Yogev* discloses that defect particles tend to explode during a laser cleaning process, and teaches away from defect fragmentizing by listing potential drawbacks of the particle explosion process, such as substrate surface damage upon the explosion, difficulty of removing particles and

particle fragments of different contaminants and large range of sizes (Col. 2, lines 1-3). Further, *Yogev* discloses that his inventive process substantially reduces or eliminates particle explosion phenomena (Col. 3, lines 25-27; Col. 4, lines 42-43; Col. 5, lines 19-20). In an exemplary process, *Yogev* discloses that none of the silicon nitride particles exploded, as compared to a conventional laser cleaning process having more than 80% of the particles exploded.

The Examiner stated that *Yogev* discloses the use of laser cleaning and the explosion of a particle and fragments thereof. Applicant submits that *Yogev* mentions particle fragmentation, but teaches away from fragmenting particles as discussed above.

In the Response to Argument, the Examiner disagreed with Applicant's argument, stated that *Yogev* teaches explosive evaporation because *Yogev* discloses: *use of laser cleaning and the explosion of a particle and fragments thereof.*

Applicant submits that *Yogev* fails to teach evaporating the particle defects with the laser. Further, applicant submits that *Yogev* teaches away from defect particle fragmentation by a laser ablation process. Thus Applicant respectfully submits that *Yogev* fails to teach an element of the present claims, namely "causing the particle defects to undergo explosive evaporation, the explosive evaporation comprising evaporation and fragmentation of the particle defects."

Applicant submits that *Yogev* mentions explosion of particle defects as a problem to be addressed, and that there is a need for cleaning integrated circuit without damaging the substrate surface upon explosion of the particle.

> *...There is a need to find a process which can be used to clean integrated circuits, without adding contaminants, without damaging the substrate surface upon explosion of a particle, and yet with removing particles, or fragments thereof, of different contaminants and of a large range of sizes.*
> (*Yogev*, Col. 1, line 60 to Col. 2, lines 3)

Thus, *Yogev* repeatedly teaches away from defect fragmentation, and discloses a process that reduces or eliminates particle fragments.

> *In some aspects of preferred embodiments of the present invention, a method and system are provided for delivering the fluid phase so as to substantially <u>reduce or eliminate particle explosion phenomena</u>. The need, in turn, to remove particle fragments is thus reduced or eliminated.*
> (Yogev, Col. 3, lines 23-29)

> *In such applications, the fluid coating has the additional advantage of* <u>*preventing the explosion of contaminant particles*</u> *due to absorption of the laser radiation. Such explosion can cause the contaminant to "splash" over the wafer surface, leaving deposits that are difficult or impossible to remove.* (Yogev, Col. 7, lines 40-45)

> *It was found that using a dry laser process, more than 80% of the particles exploded, and were therefore left on the wafer. When the vapor-enhanced narrow-gap method was performed with a coating time of 0.5 s, however,* <u>*none of the silicon nitride particles exploded*</u>*, and all were removed (100% removal). A similar trend was observed for alumina particles. It may be understood from this example that vapor-enhanced processing* <u>*alleviates particle explosion*</u> *in laser cleaning tools.* (*Yogev*, Col. 10, lines 31-38)

Thus applicant respectfully disagrees with the Examiner, and submits that *Yogev* fails to teach explosive evaporation of the particle defects, which is defined as evaporation and fragmentation of the particle defects.

In sum, applicant submits that *Reinhardt*, *Allen* and *Yogev* all are silent with respect to the process of using a laser beam for causing a particle defect to undergo an explosive evaporation, which comprises evaporation and fragmentation of the particle defect. Applicant submits that *Reinhardt*, *Allen* and *Yogev* all are silent with respect to the process of using a laser beam for vaporizing the particle defect. Also, applicant submits that Reinhardt and Allen are both silent with respect to fragmentizing the particle defect, and *Yogev* teaches away from fragmentizing the particle defect. Thus applicant submits that the combination of these references would not render obvious the present claims of laser ablating a particle defect, causing explosive evaporation of the particle defect, which comprises partial evaporation and partial fragmentation of the particle defect.

With respect to claims 21 and 28, applicant submits that dependent claims 21 and 28 are patentable, at least for the reason stated above with respect to the independent claims 17 and 25, respectively. Additionally, dependent claims 21 and 28 are patentable in view of *Reinhardt*, *Allen* and *Yogev* for the reasons stated below.

Claims 21 and 28 claim that the processing device utilizes the data of the particle defects to compute their physical properties, which the particle defect ablator can utilize

to control power, time frequency pulsing, or other electronic functions of the short pulse laser.

The present claim is patentable in view of *Reinhardt*, *Allen* and *Yogev* since these references each fails to teach at least an element of the present claims, namely utilizing data of the particle defects to compute their physical properties to help the particle defect ablator to control power, time frequency pulsing, or other electronic functions of the short pulse laser.

Applicant submits that *Reinhardt* fails to teach using physical properties of the particle defects to control power, time frequency pulsing, or other electronic functions of the short pulse laser. *Reinhardt* discloses that the laser removes the defects indiscriminant of the material and composition of such defect, as a result of the laser beam removing the defect by thermal shock (Col. 11, lines 45-48). Thus the ablation laser according to *Reinhardt* is unlikely to utilize data about the physical properties of the defect.

With regard to *Allen*, applicant submits that *Allen* is silent with respect to using physical properties of the particle defects to control power, time frequency pulsing, or other electronic functions of the short pulse laser.

Applicant also submits that *Yogev* is silent with respect to using physical properties of the particle defects to control power, time frequency pulsing, or other electronic functions of the short pulse laser.

Thus applicant submits that the combination of *Reinhardt*, *Allen* and *Yogev* does not render obvious the present claims since the prior art references of Reinhardt, Allen and *Yogev* each fails to teach using physical properties of the particle defects to control power, time frequency pulsing, or other electronic functions of the short pulse laser. The present claims are patentable in view of *Reinhardt*, *Allen* and *Yogev*.

With respect to other dependent claims, applicant submits that these dependent claims should be allowable, at least for the reason stated above with respect to the independent claims.

With respect to the rejection of claims 10-11 as being unpatentable over *Reinhardt*, *Allen*, *Yogev* and *Borden*, applicant submits that dependent claims 10 and 11

are patentable, at least for the reason stated above with respect to the independent claim 7. Additionally, dependent claims 10 and 11 are patentable in view of *Reinhardt*, *Allen*, *Yogev* and *Borden* for the reasons stated below.

Claims 10 and 11 are directed to focusing the laser beam so that a focal point of the laser beam contacts the particle defect at a low incidence angle. The low incident angle is between about 5° to about 30° from the wafer surface (claim 11). The low incident angle potentially can reduce the damage to the wafer surface caused by the laser beam. For example, during laser ablation, a high energy plasma plume may form as a result of the rapid thermal gradient. A low incident angle can cause the high energy plasma plume to shift up and away from the wafer surface, thus reducing the damage to the wafer surface. Also, the amount of reflected energy increases with a low incident angle, thus in the event that the laser beam misses the particle, the low incident angle laser beam will direct less energy into the wafer surface.

The present claims are patentable in view of *Reinhardt*, *Allen*, *Yogev* and *Borden* since these references each fails to teach at least an element of the present claims, namely directing the laser beam so that a focal point of the laser beam contacts the particle defect at a low incidence angle.

Applicant submits that *Reinhardt*, *Allen* and *Yogev* all fails to teach focusing the beam at a low incident angle from the wafer surface. It is appreciated that the Examiner also acknowledges that Reinhardt fails to teach the angle of incident (Office Action dated 7/24/2007, page 4).

With regard to *Borden*, applicant submits that *Borden* discloses applying a laser to heat the surface of a wafer to compensate for the cooling effect of the CO_2 snow spray (Col. 2, lines 1-4; Col. 2, lines 56-57; and Col. 3, lines 54-57). The size of the laser beam may be expanded to optimize heating of an area that is cooled by the snow spray. *Borden* is silent with respect to <u>focusing</u> a laser beam onto a particle defect at a low incident angle. In addition, the CO_2 spray coming from a jet spray nozzle at a shallow angle can cover a large area of the wafer, as shown in Fig. 1. Thus applicant submits that *Borden* fails to disclose focusing a laser beam onto a particle defect at a low incident angle.

In addition, applicant submits the prior art of *Borden* is incompatible with those of *Reinhardt*, *Allen*, and *Yogev* since the laser beam of *Borden* provides a different principle

of operation. *Borden* discloses using a broad laser beam for heating the wafer surface for compensating the cleaning action of the CO_2 spray, while *Reinhardt* focuses a laser beam onto a particle defect for ablation. Thus it is not obvious that the low angle of a broad laser beam for wafer surface heating can be applied to a focusing laser beam onto a particle defect for ablating the particle defect.

With respect to the rejection of claims 10-11 as being unpatentable over *Reinhardt*, *Allen*, *Yogev* and *Franca*, applicant submits that dependent claims 10 and 11 are patentable, at least for the reason stated above with respect to the independent claim 7. Additionally, dependent claims 10 and 11 are patentable in view of *Reinhardt*, *Allen*, *Yogev* and *Franca* since these references each fails to teach at least an element of the present claims, namely directing the laser beam so that a focal point of the laser beam contacts the particle defect at a low incidence angle.

Applicant submits that *Franca* discloses applying a laser to an area of a CMP pad surface, to generate steam or vapor to assist in the cleaning process (Col. 3, lines 15-16; Col. 4, lines 41-42; Col. 7, lines 48-52). The size of the irradiated area is in the order of cm (Col. 7, lines 48-52). The laser beam at a shallow angle covers a large area of the CMP pad, as shown in Figs. 2-6. *Franca* is silent with respect to <u>focusing</u> a laser beam onto a particle defect at a low incident angle. Thus applicant submits that *Franca* fails to disclose focusing a laser beam onto a particle defect at a low incident angle.

In addition, applicant submits the prior art of *Franca* is incompatible with those of *Reinhardt*, *Allen*, and *Yogev* since the laser beam of *Franca* provides a different principle of operation. *Franca* discloses using a broad laser beam for heating the surface of a CMP pad, generate steam or vapor to assist in a pad cleaning process. Thus it is not obvious that the low angle of a broad laser beam for CMP pad heating can be applied to a focusing laser beam onto a particle defect for ablating the particle defect.

With respect to the rejection of claim 12 as being unpatentable over *Reinhardt*, *Allen*, *Yogev* and *Patel*, applicant submits that dependent claim 12 is patentable, at least for the reason stated above with respect to the independent claim 7. Additionally, dependent claim 12 is patentable in view of *Reinhardt*, *Allen*, *Yogev* and *Patel* since these references each fails to teach at least an element of the present claim, namely focusing the

laser beam so that a focal point of the laser beam to be above the wafer surface at a distance approximately equivalent to the approximate radius of the particle defect.

Claim 12 is directed to focusing the laser beam to a point above the wafer surface at a distance approximately equivalent to the approximate radius of the particle defect. Focusing the laser beam at the particle radius can minimize the laser power and at the same time, reduce the damage to the wafer surface caused by the laser beam. For example, during laser ablation, a high energy plasma plume may form as a result of the rapid thermal gradient. Focusing above the wafer surface can cause the high energy plasma plume to be further away from the wafer surface, thus reducing the damage to the wafer surface. However, if the laser beam is focused too far from the particle defect, the energy transferred to the particle defect is reduced accordingly. Thus to achieve the same transferred energy to the particle defect with a focal point far the particle defect, the laser energy needs to be increased proportionally. Applicant submits that the present claim 12 provides an optimum focal point for the present laser ablation process, focusing at approximately the particle radius, thus achieving maximum power transferred and minimum energy damage to the wafer surface.

The present claims are patentable in view of *Reinhardt*, *Allen*, *Yogev* and *Patel* since these references each fails to teach at least an element of the present claims, namely focusing the laser beam to position a focal point of the laser beam to be above the wafer surface at a distance approximately equivalent to the approximate radius of the particle defect.

Applicant submits that *Reinhardt* fails to teach focusing the beam to a point above the wafer surface. *Reinhardt* discloses directing a laser beam at the particle defect to remove such defect by thermal shock, but *Reinhardt* is silent with respect to the location of the focal point of the laser beam. Thus *Reinhardt* fails to teach focusing the beam to a point above the wafer surface.

With regard to *Allen*, applicant submits that *Allen* discloses coating the substrate surface with a transfer medium, and then directing a pulsed energy source (e.g., a laser beam) to the substrate to cause explosive evaporation on the transfer medium. *Allen* is silent with respect to focusing the beam to a point above the wafer surface. Thus *Allen* fails to teach focusing the beam to a point above the wafer surface.

With regard to *Yogev*, applicant submits that *Yogev* discloses applying laser energy to the surface to aid in the release of the particles from the surface. However, *Yogev* is silent with respect to focusing the laser to position a focal point of the laser beam to be above the wafer surface at a distance approximately equivalent to the approximate radius of the particle defect.

With regard to *Patel*, applicant submits that *Patel* discloses focusing a beam of laser in a plane above the substrate surface to minimize damage to the surface. By focusing on a plane above the surface, the energy reaching the surface is reduced, and thus the damage to the substrate surface is also reduced. However, as shown in Figs. 1 and 2, the energy transferred to the particle defect is also reduced. Thus in essence, *Patel* discloses reducing damages on the substrate surface be reducing the energy reaching the particle defects. In other words, to provide the same energy to the particle with an above-surface focus, the laser beam will need to have a higher power, which then will provide the same amount of high damage to the substrate surface.

Thus applicant submits that the present claim of focusing the laser beam at the radius of the particle defect is not obvious in view of *Patel*, in combination with *Reinhardt*, *Allen* and *Yogev* since by focusing the laser beam at the radius of the particle defect, the energy transferred to the particle remain the same and the energy damaging the substrate surface is reduced.

With respect to dependent claims 12 and 17, applicant submits that these dependent claims should be allowable, at least for the reason stated above with respect to the independent claims.

In conclusion, applicants respectfully submit that in view of the amendments and arguments set forth herein, the applicable rejections have been overcome.

Pursuant to 37 C.F.R. § 1.136(a)(3), applicant(s) hereby request and authorize the U.S. Patent and Trademark Office to (1) treat any concurrent or future reply that requires a petition for extension of time as incorporating a petition for extension of time for the appropriate length of time and (2) charge all required fees, including extension of time fees and fees under 37 C.F.R. §§ 1.16 and 1.17, to Deposit Account No. 02-2666.

Respectfully submitted,

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN

Date: April 3, 2009

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